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SPECIAL ARTICLES

WHITE CORN VS. YELLOW CORN AND A PROBABLE RELATION BETWEEN THE FAT-SOLUBLE VITAMINE AND YELLOW PLANT PIGMENTS

As the importance of the vitamins in the physiological economy of the animal is coming to be appreciated, observations on their occurrence and their distribution in nature are being rapidly accumulated in various laboratories. As is to be expected, with data on vitamin distribution available, there is a growing inclination to deduce therefrom, not only evidence as to their possible rôle in living organisms, but also a suitable working hypothesis enabling one to predict in an unknown whether the amount of vitamin is liable to be large or small. Furthermore, from the viewpoint of the chemist, it scarcely needs to be emphasized what a step in advance it would be if from their occurrence in nature an idea could be obtained as to their possible chemical character.

We are still far distant from this goal in the case of the anti-scorbutic and anti-neuritic vitamins, but in the case of the fat-soluble vitamin, the mere fact—as its name indicates—that it is soluble in fats and also its solubility in many fat solvents excludes from consideration many compounds.

Two years ago the writer experienced some difficulty in getting rats to rear their young on a ration which, to a considerable extent, consisted of corn. Failure was often indicated by an inflammation of the eyes—a xerophthalmia, which Osborne and Mendel¹ first indicated as evidence of a deficiency of the fat-soluble vitamin. No further attention was paid to this difficulty beyond modifying the ration to increase its content of this dietary essential. Later, however, rats were again put on a similar ration and no difficulty was experienced. With many other apparent inconsistencies arising in a colony of a thousand animals, and all of them bearing investigation no immediate attention was given to this matter.

¹ T. B. Osborne and L. B. Mendel, *Jour. Biol. Chem.*, 16, 431, 1913.

During the course of the past year a considerable amount of work dealing with the occurrence of the fat-soluble vitamin in roots was completed. It was indicated that, while the colored roots such as carrots and sweet potatoes are rich in this dietary essential, sugar beets, mangels, dasheens and Irish potatoes contain little or none of it. It was then recalled that at the time that the difficulty with female rats to rear their young had been observed, it had been impossible to obtain sound yellow corn on the local market and white corn had been used instead. This had been done in a part of the stock colony and as the conditions for its maintenance are fairly well standardized and not always under close personal supervision the relation between the slight modification in the ration and the disastrous results had not been detected.

It has now been conclusively demonstrated with eight different varieties of corn which are extensively grown in the middle west, that while white corn contains no demonstrable amounts of the fat-soluble vitamin, yellow corn may contain sufficient amounts to allow normal growth and reproduction in the rat. One rat has successfully reared her young after having been fed yellow corn suitably supplemented with vitamin-free protein and salts for seven months. On white corn, similarly supplemented, young rats usually die in three months with the typical symptoms of a fat-soluble vitamin deficiency.

These relations suggested the possibility of correlating other instances of the simultaneous occurrence of the fat-soluble vitamin and yellow plant pigments. We have at hand the interesting observation of Osborne and Mendel² that while the oleo oils contain the vitamin, the solid beef fats do not. They state specifically that the oleo oils were yellow while the solid fats were colorless. Furthermore, they were also able to separate the butter fats by fractional crystallization into an active fraction of the liquid fats—which was yellow—and an inactive fraction—which was colorless.

² T. B. Osborne and L. B. Mendel, *Jour. Biol. Chem.*, 20, 379, 1915.

In an investigation of the nutritive properties of commercial oleos and their ingredients, the writer and coworkers³ have found a considerable difference in their vitamine content. It is significant that of the oleo oils those most highly pigmented were also the richest in fat-soluble vitamine and those least pigmented were the poorest. This, in view of the present prevailing conception of the importance of the vitamine content of certain fats in the diet, is a matter of such great economic significance that comment on it is reserved until the investigations now in progress shall have been completed. It is mentioned here merely to indicate why it is considered possible that the fat-soluble vitamine may be one of the yellow pigments or a closely related compound.

In scores of feeding experiments in which butter fat as prepared from ordinary butter has been used as the source of the fat-soluble vitamine we have repeatedly observed variations in the vitamine content. It has not been possible to correlate this with the degree of pigmentation—which is well known to vary with the feed and the breed of the dairy cow—as the amount of natural pigment present had been concealed by the addition of butter color. One fact however appears particularly significant, and that is, that when butter fat is heated its vitamine is destroyed and simultaneously there occurs a destruction of its pigment.³ Whether this is an accidental coincidence or one and the same thing remains to be seen.

From the evidence submitted it appears reasonably safe, at least as a working hypothesis, to assume that the fat-soluble vitamine is a yellow plant pigment or a closely related compound, which view, moreover, is strengthened by the fact that we know through the work of Palmer and Eckles⁴ of the inability of the animal to synthesize the yellow pigments carotin and xanthophyll. From its occurrence in butter, in leaves, in carrots and in other materials known to be rich in carotin,

³ H. Steenbock, P. W. Boutwell and Hazel E. Kent, *Jour. Biol. Chem.*, 35, 517, 1918.

⁴ L. S. Palmer and C. H. Eckles, *Jour. Biol. Chem.*, 17, 211, 223, 237, 245, 1914.

it might be concluded that we were here concerned with carotin. Some data, that we have accumulated have answered this in the negative and it has been so reported,⁵ but it appears doubtful if much importance can be attached to these earlier results as we have since observed that carotin under certain conditions is a very labile compound. We do not desire to mislead our readers by indicating that we have conclusive evidence one way or another.

Provisionally, we are assuming that the fat-soluble vitamine is one of the yellow plant pigments, but we are not unmindful of the possibility that the reasons for the association of these properties in nature, viz., yellow pigmentation and this growth-promoting property may be a genetic one in some cases, while in others it may be indicative of mere similarity in physical if not chemical properties. If it is not a pigment, no doubt, instances will soon be found where it is found to occur liberally in non-pigmented materials. We already have indications that certain materials are as rich in the fat-soluble vitamine as is yellow corn, yet they are far less pigmented. Whether this can be explained in difference of kind of pigment which in yellow corn is known to be principally xanthophyll or whether we are dealing in these instances with the leuco compound remains to be seen.

It is scarcely necessary to elaborate on these findings or to point out their possible economic significance. Many investigations based on the general premises which we have here outlined are now in progress and will be reported as the evidence obtained seems to warrant a detailed discussion.

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THE twenty-sixth summer meeting of the society was held at the University of Michigan, September 2-4, in conjunction with meetings of the Mathematical Association of America and the

⁵ H. Steenbock, P. W. Boutwell and Hazel E. Kent, *Proc. Amer. Soc. Biol. Chem.*, 1919.